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V describes a circle and the angle ϕ is constant. Cremona's optical problem admits either of no solution or of an infinite number of solutions and the angle ϕ does not depend on the angles ϕ_i of even indices.

We have therefore proved the following proposition:

If rays of light emanate from a fixed source which, in succession, are reflected on n straight lines (mirrors) then the final reflected rays cut the corresponding original rays in points of a conic which is not or is a circle according as n is odd or even. In the first case (n odd) there are two places on the conic where the original and final rays make a given angle. In the second case (n even) there are no such places on the circle, or else an infinite number. In this case (n even) the angle ϕ only depends on the angles between succeeding reflecting lines, whose orders in this succession are odd.

6. APPLICATIONS. Let $n=2$, then $\phi=\pi-2\phi_1$. To make $\phi=\frac{1}{2}\pi$, we must choose $\phi_1=45^\circ$. This is illustrated in Fig. 2, and is practically applied in Adams' Angle Mirror* or Optical Square.

For $n=4$, $\phi=3\pi-2(\phi_1+\phi_3)$.

To make $\phi=\frac{1}{2}\pi$, $\phi_1+\phi_3$ must be made equal to $\frac{5}{4}\pi$. Under this condition ϕ_1 and ϕ_3 may vary separately. The condition is also satisfied by taking $\phi_1=\phi_3=\frac{5}{8}\pi=112^\circ 30'$, and this is illustrated in Fig. 3.

DEPARTMENTS.

SOLUTIONS OF PROBLEMS.

ALGEBRA.

Solutions of Problem 188 have been received from J. E. Sanders, Hackney, Ohio, and Charles A. Carpenter, Student in Adelphi Academy, Brooklyn, N. Y.

189. Proposed by S. F. NORRIS, Professor of Astronomy and Mathematics, Baltimore City College, Baltimore, Md.

$$\text{Solve } 3x-y=xy-x^2, \quad \sqrt[3]{y}=\sqrt{\frac{2y-x}{2}}.$$

Solution by G. B. M. ZERR, A. M., Ph. D., Parsons, W. Va.

$$\text{From the first equation, } y=\frac{x^2+3x}{x+1}.$$

$$\therefore \sqrt[3]{\frac{x^2+3x}{x+1}}=\sqrt{\frac{x^2+5x}{2(x+1)}}.$$

$$\therefore x^2(x^4+7x^3+19x^2+5x-72)=0.$$

$$\therefore x=0, 1.442, -3.65, -2.396 \pm 2.829\sqrt{-1};$$

$$y=0, 2.623, -.895, 7.583 \mp .423\sqrt{-1}.$$

*Invented by George Adams in London in the middle of the 18th century and first described by his son in 1791.